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Determination of Radon and Uranium Concentrations in soil samples Iraqi cities

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ABSTRACT

In this investigation the concentrations of radon and uranium levels in 180 soil samples distributed in 18 cities in Iraqi Country have been measured using long term technique for alpha particles emission with solid state nuclear track detecror type CR-39 .

The maximum concentrations of radon was (261.54Bqm-3) in soil sample No. (18) : Basra city , while the minimum activity was (86.80 Bqm-3) in soil sample No. (6): Salahaddin city. The uranium concentrations in the same cities have been measured in (ppm) unit the maximum concentration was (0.0201) in soil sample No. (18):Basra city , while the minimum activity was (0.0067) in soil sample No. (6):Salahaddin city.

The variable values of radon and uranium concentrations may be mentioned that Iraq cities have variable geologies ,despite the limitation of existing data the observational and experimental data presented here is the first investigation and study provided a basis for the radon and uranium map in whole Iraq.

Keywords

Nuclear track detector; CR-39; Radon and Uranium concentrations; soil

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INTRODUCTION

The polymer Solid State Nuclear Track Detectors (SSNTDs) such as CR-39 and CN-85 are very sensitive to the energetic alpha-particles since they cause intense damage trail as it passing through them . So, CR-39 and CN-85 as well as LR-115(II) are used widely for detecting and measuring the α -particle emitter isotopes such as radon gas [1-7] and Uranium [8,9].The concentration of the radioactive materials is correlated with the number of etched tracks per unit area of the detector surface(tracks density),which can be counted with the aid of an optical microscope. This visual counting method is replaced by the measurement of the optical density [10, 11],or the diminishing in the laser beam intensity as it transmit through the etched SSNTDs [12,13].

In the natural environment, radon element has three radioactive isotopes, namely: ^{222}Rn (3.82 d), ^{220}Rn (55 s) and ^{219}Rn (4 s). Normally, ^{220}Rn and ^{219}Rn and their progenies are neglected when studying "radon problem" [14, 15]. The immediate radon precursor is Radium (226Ra), with a half-life of 1600 years, spread widely, particularly in materials which are made from mineral products. The forerunner of radium is Uranium (^{238}U); which has a half-life of 4.47×10^{9} years [16]. Radon is picked up by ground water passing through rocks and soil containing such radioactive substances; it enters water supplies when this water is pumped up a well [17].

Materials and Methods :

Collection of soil samples :180 samples of soil distributed in 18 cities in Iraqi Country were taken from location of study, from depth (5 cm) as 10 samples for each city as shown in fig.(1) . Then the samples were cleaned, dried in an oven at 70Co for 12 hours finally they were powdered and sifted by using special sieve (250 µm in diameter) [15]. which are available in market were analyzed. For each sample about 20 gms of soil was kept in a small clean vial (10 cm height and 2.2 cm diameter) and marked with a proper number for identification. Solid State Nuclear Track Detectors (SSNTD) with sheet thickness 300µm were used in this study, which is usually known as CR-39 plastic detector [16,17].The detectors were small square pieces of size 1cm × 1cm covered with plastic properly and hung inside the sample of the vial [18]. The open mouths of vial were closed properly and then preserved in suitable place free from disturbance. After completion of the exposure, these were etched in (6.25 N) NaOH solution at a constant temperature of 70±10Co for six hours in a constant water bath. After removal, the detectors were etched with a sharp pin simultaneously in a beaker. For immersing a detector in the beaker and to let it stand erect each detector was fixed with a paper clip properly at the bottom of the beaker [19]. The central portion of the detector strips was scanned by using a microscope (kruss-mbl 20000) at a magnification of 400(40x objective and 10x eyepiece). The determinations of the concentrations of alpha particles from radon gas in samples were performed by using CR-39 from the intercast Europe srl company. The alpha tracks per cm2 in each detector were determined using an optical microscope.

The radon gas concentration in samples was obtained by using the sealed-cup technique as shown in Fig.2.The test tubes were sealed and stored for 85 days (from 1-7-2013 to 23-9-2013).

Fig.(1): Samples of soil distributed in 18 cities in Iraqi Country

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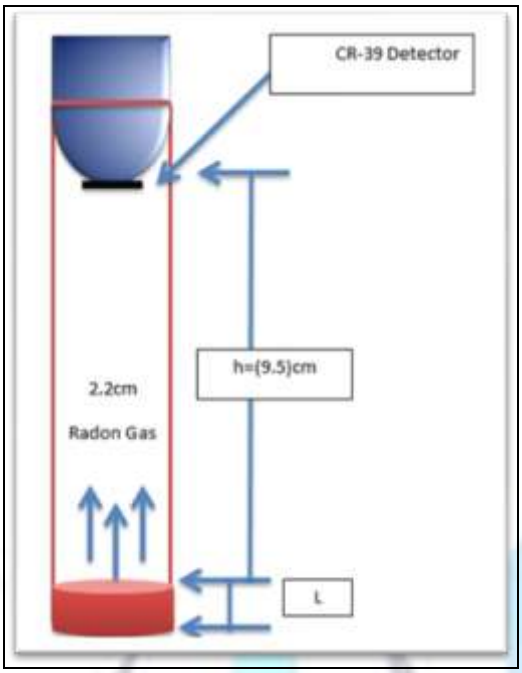

Fig.(2): The test tubes were sealed and stored for 85 days

Results and Discussion :

For the purpose of calculating ^{222}Rn concentration levels in soil samples, the radon activity density (C) in the air gap above the soil samples were determined by measuring the tracks density on the detector according to the following relation[20]:

$$C = \frac{\rho}{KT} \dots\dots\dots (1)$$

Where C is the ^{222}Rn concentration in the test tube above the sample measured in (Bq/L), ρ is the surface density of tracks on the exposed detectors(Tr/cm^2), T is the exposure time(85 day) and K is the ^{222}Rn gas diffusion constant [21]. Such that

$$K = \frac{1}{4} r \left(2cos\theta_c - \frac{r}{R_\alpha}\right) \dots\dots\dots\dots (2)$$

Where r is the test tube radius (1.1cm), θ_c is the critical angle for CR-39 (35degree) and R_α is the range of ^{222}Rn alpha particle in air (4.15 cm) [21]. By substituting r, $\theta_c$and R_α in equation(2) we get:-

$$K = 0.377cm \dots\dots\dots\dots (3)$$

The radon activity density in the soils samples (C_{Rn}) in the test tube was calculated by using a model proposed by Somogyi [22]. According to this model, the number of radon atoms exhaled from the sample surface is equal to the number of radon atoms in the can air above the soil samples multiplied by the probability of decay, which can be written in the following form [22]:

$$C_{Rn} = \lambda ChT/L \dots\dots\dots\dots (4)$$

where λ is the decay constant of (^{222}Rn) = 7.554×10^{-3}(hr^{-1}), h is the distance from the surface of soil in the sample cup to the detector (9.5 cm), T is the exposure time of the sample (2040 hr) and Lis the depth of the samples (0.5cm). The activity of (^{222}Rn) in the soil samples will be calculated in (Bq) unit from the following relation:

$$A_{Rn} = C_{Rn} V \dots\dots\dots\dots (5)$$

Where V is the Volume of the sample in the test tube

$$V = \pi r^2 L(m^3) \dots\dots\dots\dots (6)$$

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The experimental results obtained in this work for Radon and Uranium Concentrations levels in different types of soil samples in Iraqi cities are presented in table 1.

Table 1. Radon and Uranium Concentrations in soil samples in Iraqi cities

Samples Name	Samples Numbers	Average C_{Rn} (Bq/m^3)	Average $C_{Rn}\times10^{-4}$ (Bq)	Average C_U (ppm)
S1:Duhuk	10	140.86	2.68	0.0108
S2:Musel	10	163.70	3.11	0.0126
S3:Erbil	10	165.99	3.15	0.0127
S4:Karkuk	10	197.97	3.76	0.0152
S5:Sulamaniya	10	166.75	3.17	0.0128
S6:Salahaddin	10	86.80	1.65	0.0067
S7: Dayala	10	87.18	1.66	0.0067
S8:Anbar	10	94.41	1.79	0.0072
S9:Baghdad	10	251.27	4.78	0.0193
S10:Wast	10	178.17	3.39	0.0137
S11:Babl	10	124.49	2.37	0.0095
S12:Karbala	10	127.54	2.42	0.0098
S13:Najaf	10	140.48	2.67	0.0108
S14:Kadsia	10	143.91	2.74	0.0110
S15:Masan	10	126.77	2.41	0.0097
S16:Theqar	10	132.87	2.53	0.0102
S17:Muthanaa	10	245.17	4.66	0.0188
S18:Basra	10	261.54	4.97	0.0201
Max.	Total number of samples 180	261.54	4.97	0.0201
Min.		86.80	1.65	0.0067
Average		159.21	3.03	0.0122

The maximum concentration was (261.54Bqm^{-3}) in soil sample No. (18): Basra city , while the minimum concentration was (86.80 Bqm^{-3}) in soil sample No. (6):Salahaddin city. The uranium concentrations in the same cities have been measured in (ppm) unit the maximum concentration was (0.0201) have been observed in soil sample No. (18):Basra city , while the minimum activity was (0.0067) has been observed in soil sample No. (6):Salahaddin city .

The variable values of radon and uranium concentrations may be mentioned that Iraq cities have variable geologies ,despite the limitation of existing data the observational and experimental data presented here is the first investigation and study provided a basis for the radon and uranium map in whole Iraq.

Conclusion :

In this investigation the concentration of radon in Iraqi country cities soil have been measured. We found that the uranium levels in whole soils samples in this field of study within the acceptable value (11.8 ppm) in addition to the radon concentrations in all soil samples was less than the safety limit .

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